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PUBLIC HEALTH REPORTS

VOL. 37 JULY 21, 1922. No. 29

DERMATOSIS FOLLOWING THE USE OF CUTTING OILS AND LUBRICATING COMPOUNDS.

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Introduction.

The study covered by this report was undertaken in response to appeals from many industrial plants which requested the United States Public Health Service to instruct them in available methods for preventing the dermatosis resulting from the use of cutting oils and compounds.

Scientific Assistant Forrest Edwards Deeds was first assigned to the study, which was begun in January, 1919, and much of the material contained herein was collected by him. Later the writer was detailed to complete the study and to prepare a report of the work.

The study was confined for the most part to the larger plants in the cities of Chicago, Minneapolis, and St. Paul, and managers and workers heartily cooperated with the investigators. Methods recommended for the prevention of the trouble were tried out by the men in a few plants, with the result that the skin lesions improved very rapidly and no new lesions appeared.

Since the object of the study was to determine if possible the exact cause of the dermatosis and to suggest preventive measures, some portions of the study are apparently digressive and irrelevant to the dermatosis itself. For this reason the work is divided into two sections, as follows: Part I. Cutting oils and lubricating compounds; Part II. Cutting-oil dermatosis.

Part I. Cutting Oils and Lubricating Compounds.

ADVENT OF CUTTING OILS AND COMPOUNDS.

The introduction of high-speed metal-cutting machines in industry gave rise to the study of methods for minimizing the heat caused by friction between the cutting tool and the metal under operation. If no preventive measures are taken, this heat becomes so excessive that the temper of the metal is drawn and the cutting edge of the tool breaks down very rapidly; and there is a resultant loss of time in removing the old tool and inserting a new one, not to mention the loss involved in the cost of the tool itself. Moreover, when accuracy of measurement of the cut piece is required, excessive heat is detrimental, for the reason that it causes an expansion of the metal, so that, upon cooling, unless very great precaution has been observed, the piece may be undersized.

In 1883, according to Taylor,[1] the fact was first demonstrated that a stream of water poured directly upon the cutting lip of a cutting tool would make possible an increase in cutting speed, with a resulting increase of from 30 to 40 per cent in the amount of work done.

This idea was first utilized industrially in 1884, by the Midvale Steel Works, under the supervision of Taylor. The water which fell from the machines was caught in wrought-iron pans surrounding the machines; but in consequence of this arrangement the machines soon became rusted from the action of the water, and, moreover, the high specific heat of water rendered its use for this purpose still less satisfactory. To obviate this difficulty, soda was added to the water. The solution so formed served the purpose of a "coolant" or "refrigerant," but possessed no lubricating properties, and left a deposit on the machine. Oils were then tried and were found satisfactory. Lard oil became for a time the most popular of lubricating oils; but on account of the high cost of lard oil and the fact that it has a tendency to gum, experimentation was begun with the idea of combining cheaper oils with water, and the mixtures evolved became known as cutting compounds.

CLASSIFICATION OF LUBRICANTS.

Cutting fluids may be grouped into two broad classes, namely, cutting oils and cutting compounds. Cutting oils are pure animal, vegetable, or mineral oils, or mixtures of any of these.

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[1] Taylor, F. W.: On the Art of Cutting Metals, p. 9. 1906.

Animal oils, of which lard, sperm, fish, and whale oil are examples, have been used with varying success. Lard oil, when clear and free from rancidity and adulteration, is very satisfactory for all classes of work. The composition of lard oil differs, however, and is graded upon its free fatty acid content, the poorest having a high and the best a low percentage of this constituent. Sperm oil and fish oil, as also whale oil, have been used to some extent. But whale oil, unless combined with other oils, is unsuitable for this use, on account of its drying properties.

Olive oil, the most popular of the vegetable oils, is less viscid in cold weather than lard oil, and flows more freely. Cotton seed, rape, and rosin oils are used occasionally as components of mixed oils and compounds.

The objection to animal and vegetable oils is that the oil film frequently breaks down, because of the decrease of viscosity with increase of temperature.

A mixture of lard oil with a mineral oil, in varying proportions, constitutes the most important of the mixed oils. Mixtures which have from 50 to 70 per cent of mineral oil are termed mineral lard oils. The efficiency of the mixture depends upon the lard oil content, which also affects the cost. Adulterants are frequently used, therefore, to lower the cost. The adulterants commonly used are rosin oil, cottonseed oil, rape oil, aluminum soap, and lead soap. The latter two substances are employed also to increase the viscosity of some of the mineral oils of low viscosity.

The above-mentioned oils, which are used without further treatment, are known as "straight" oils, in contra-distinction to "soluble" oils, or oils which form milky emulsions when mixed with water and soluble materials.

Sulphonated oil is an example of these soluble oils. By heating castor oil, cottonseed oil, olive oil, and some others, with sulphuric acid, a sulpho-compound is formed. When the excess acid content is neutralized by an alkali, after the addition of sodium chloride to the mixture, a sulphonated oil base results. The base is mixed with a mineral oil in such proportion that all the oil is held in emulsion when water is added to the resultant mixture. Oils of this class are likely to contain free sulphuric acid and fatty acids. A small amount of a mineral oil, such as kerosene or gasoline, is frequently added.

Soap oils, which are further examples of soluble oils, are prepared by mixing mineral oils and saponifiable oils, either vegetable or animal. The oils are saponified with an alkali to form soaps, which, when mixed with water, hold the mineral oil in suspension and form creamy emulsions. When cheapness is desired, free fatty acids are used to form the soaps and are mixed with the oil to be carried in suspension.

When carbolic acid and an alkali are added to a suitable oil, the resulting mixture is known as a "phenolated" oil. Phenolated oils are not in general use.

Graphite is held in suspension in oil or water to which small quantities of gallo-tannic acid have been added, and the resultant mixture is marketed as a cutting oil under various trade names.

Many manufacturers prepare their own cutting emulsions, and because of this fact it is not possible to enumerate all the cutting emulsions used. Machine oil, caustic soda, denatured alcohol, and kerosene enter into some compounds. It is a significant fact that no particular oil or emulsion has been accepted as a standard for any one operation. The object is to select a lubricant having the least cohesion consistent with the varying condition of the problem on hand. The choice depends upon the judgment and preference of the individual manufacturer. He is influenced by character of machine, hardness of metal, and use of low speed and shallow cut, high speed and shallow cut, low speed and heavy cut, or high speed and heavy cut.

ANALYSES OF OILS.

While the composition of emulsions used is to a certain extent a trade secret, this secrecy is not general, and so several typical oils and oil mixtures in use were analyzed in connection with the study. The analyses were made by the United States Bureau of Standards. In reading the results of these analyses, which follow, it is well to bear in mind the fact that the soluble oils and refrigerant bases are not used straight, but are diluted. The emulsifying agent is first added to the oil, and the resulting mixture is diluted with water to form an emulsion—usually 1 part of the oil mixture with 5 to 8 parts of water. Therefore the percentage composition of the resultant emulsion is proportionately reduced. The refrigerant bases are mixed with mineral oils, paraffin oil, kerosene, or a mixture of these, in the ratio of 1 part of base with 5 to 8 parts of diluent.

TABLE I.—*Character of oils.*

	Kind of oil and laboratory number.					
	Soluble oil (60268).	Soluble oil (60269).	Refrigerant base (60270).	Mineral oil (60271).	Lard oil (60272).	Lard oil plus mineral oil (60273).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total saponifiable matter	25.0	10.1	37.3	21.4	63.5	15.3
Total fatty acids	27.0	17.1	....	....	....	....
Free fatty acids	14.30	5.12	....	....	14.9	1.14
Fatty acids as soap	12.70	12.0	....	....	....	....
Mineral oil	75.0	89.9	62.7	78.6	....	84.7
Total volatile matter	14.2	6.1	....	....	....	3.8
Free acid	....	....	....	3.32	....	....
Sulphur	....	....	3.25	....	....	....
Fatty sulpho acids	.01	(1)	....	....	....	....

TABLE I.—*Character of oils*—Continued.

	Kind of oil and laboratory number.					
	Cutting oil (60274).	Refrigerant base (60275).	Mineral oil (60276).	Paraffin oil (60277).	Mineral oil (60278).	Mineral oil (63440).
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Total saponifiable matter	32.4	10.9	5.2		9.8	26.0
Total fatty acids	36.0					
Free fatty acids	17.7					
Fatty acids as soap	18.3					
Mineral oil	67.6	89.1	94.8		83.2	74.0
Total volatile matter	17.7					8.68
Free acid				0.05	1.80	
Sulphur		9.20			1.65	
Fatty sulpho acids	.62					
Saturated hydrocarbons				95.0		
Unsaturated hydrocarbons				5.0		33.0

[1] Trace.

The foregoing table gives a fair idea of the chemical composition of some of the more common oils.

O. H. Schunk,[2] of the Hygienic Laboratory, United States Public Health Service, gives the typical analyses of a sulphonated oil and a soap oil as follows:

TABLE II.—*General composition of sulphonated oil.*

	Per cent.
Total saponifiable matter	15.57
Total fatty acids	12.56
Free fatty acids	12.08
Fatty acids as soap	.21
Mineral oil	.62
Total volatile matter	25.35
Volatile mineral oil	18.30
Nonvolatile mineral oil	59.27
Fatty-sulpho acids	15.34
Neutral fatty oil	.62
Water, ammonia, alcohol, etc	7.05

This is described as a clear, urine-red, soluble oil. "A light mineral oil, such as kerosene or gasoline, is present, as shown by the high percentage of total volatile matter. This oil is a sulphonated oil, as shown by the large amount of free fatty acids present, and no soap. The total saponifiable matter in such an oil is present in the form of sulphoacids."

TABLE III.—*General composition of soap oil.*

	Per cent.
Total saponifiable matter	16.37
Total fatty acids	16.05
Free fatty acids	4.68
Fatty acids as fat	3.71
Fatty acids as soap	7.66
Soap	8.26
Neutral fatty oil	4.03
Mineral oil	76.26
Water, alcohol, etc	7.00

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[2] Special Report, Office of Industrial Hygiene, United States Public Health Service.

The suggestion was advanced that during use the oils present in the cutting-oil mixtures are possibly changed in their chemical composition by the heat generated in the process of cutting. A series of experiments was run with this object in view. The tests were conducted upon automatic screw machines of the four-spindle type. Six different classes of oil mixtures, selected after careful study of 200 replies to questionnaires concerning the character of oils and compounds used by metal-working factories, were used upon the machines in these tests. The following are those selected:

1. Light mineral oil, used unmixed.
2. Mixture consisting of one part of "H" refrigerant base and eight parts of "H" blending oil (a mineral oil).
3. Mixture consisting of one part of "S–K" refrigerant base and eight parts of paraffin oil.
4. Mixture consisting of one part of "S–K" refrigerant base and eight parts of mineral oil.
5. Mixture consisting of two parts of a special mineral cutting oil and one part of paraffin oil.
6. Mixture consisting of one part of "H" refrigerant base and eight parts of paraffin oil.

The machines in which the oils were used were of the individual oil-supply type. Stock mixtures of the above oils were made and the oil reservoirs were filled with the oils. Although it was impossible to use the same oil throughout the test, because of the fact that oil is lost through being carried away with the finished parts, the original sample was approximated by thoroughly draining the finished parts and then adding only enough fresh stock to replace the loss.

Chemical analyses were made upon samples of the oil at the beginning of the test run and then at intervals of seven days. The machines were in use sixteen hours each work day. The metal worked upon was a nickel steel.

Table IV gives the results of these tests.

Table IV.—*Analyses showing changes in chemical composition of oils after use.*

Key number.	Laboratory number.	Total saponifiable matter.	Mineral oil.	Free acid.	Saturated hydrocarbons.	Unsaturated hydrocarbons.	Sulphur.	Mineral acid.	Free fatty acid.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	60279	29.5	70.5	4.60					
2	60283	18.9	81.1	2.13			1.41		
3	60284	22.2	77.8	.55			.96		
4	60280	19.8	80.2	1.02			.84		
5	60281	4.1	95.9	1.43	83.0	17.0			
6	60282	16.8	83.2	1.80			1.65		

TABLE IV.—*Analyses showing changes in chemical composition of oils after use*—Contd.

SEVEN DAYS LATER.

Key number.	Laboratory number.	Total saponifiable matter.	Mineral oil.	Free acid.	Saturated hydrocarbons.	Unsaturated hydrocarbons.	Sulphur.	Mineral acid.	Free fatty acid.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
1	62502	11.9	88.1			27.0			2.49
2	62503	13.5	86.5	0.83		13.0	1.18		
3	62504	9.1		.73		10.0	.74		
4	62505	16.7	83.3	1.23		20.0	.70		
5	62506	13.0		1.58		15.0			
6	62507	14.4		2.5		25.0	.98		

FOURTEEN DAYS LATER.

Key number.	Laboratory number.	Total saponifiable matter.	Mineral oil.	Free acid.	Saturated hydrocarbons.	Unsaturated hydrocarbons.	Sulphur.	Mineral acid.	Free fatty acid.
1									
2	62436	8.2	91.8	0.43		17.0	0.89		
3									
4	63437	13.5	86.5	.73		30.0	.67		
5	63438	5.2	94.8	1.07		12.0			
6	63439	16.0	84.0	1.33		27.0	1.39		

It will be seen from the table that the unsaturated hydrocarbons do increase upon use of the oil in the machine.

USES OF CUTTING OILS AND COMPOUNDS.

The use of cutting oils and compounds has become so universal that few machine shops, however small, do not employ them to some extent in the cutting of metal and alloys. "Cutting" of metal means working upon metal in the processes of turning, reaming, broaching, threading, boring, forming, drilling, tapping, grinding, sawing, and like processes.

The chief metals which are subjected to these processes are steel, iron, brass, bronze, copper, aluminum, and Monel metal.

The machines on which the above-named processes are carried on are lathes, boring mills, drills, planers, power hack saws, shapers, grinders, gear cutters, hobbers, punch presses, milling machines, stamp presses, automatic screw machines, and others.

As has already been indicated, the important problem which interested investigators was that of devising the best method for eliminating the heat factor; and the use of cutting oils and emulsions is the result of their studies. The terms "coolant" and "refrigerant" are frequently applied to these oils and compounds, because of their cooling properties.

However, the use of these oils and emulsions is advantageous in other respects also. For instance, in deep drilling, milling, and certain other machining operations, the accumulation of chips which result from the cutting processes hampers the operation of the machine. The cutting fluid serves the purpose of washing these chips away. Again, in machining such materials as low-carbon steel, the lubricating action of the oils is essential, because, without it, the chip curling back over the tool would produce a bearing which would cause a high frictional resistance, with ensuing heat. These oils likewise protect the metals against corrosion and rust, and insure a good finish on the work.

For the theory of lubrication, cooling, unit pressure, design of bearings, and relative value of the combination of depth of cut, feed, and cutting speed for different kinds of work, the reader is referred to standard textbooks on these subjects.

APPLICATION OF OILS AND COMPOUNDS.

Various methods are used in applying the oil to the work. Frequently, where the amount required is small, a brush or a "dauber," made of waste wound around a wooden rod, is used for the purpose of applying the oil. The so-called "drip-can" method consists in suspending above the work plane a small can with a hole punched in the bottom, through which the oil passes. A delivery tube of some flexible material is sometimes attached in order to direct the flow upon the cutting tool.

The larger plants usually apply the oil by forcing it, by means of a pump, through pipes which lead from a supply tank or reservoir. A pump may serve one or more machines. The central distributing system, which is used in many plants, is preferable to the individual system, and consists of a central oil reservoir from which the oil may be forced by means of pumps or of gravity through pipes to the individual machines.

RECLAMATION OF OILS AND COMPOUNDS.

As an economic measure, oils are repeatedly reused. The method of saving the waste oil for reuse depends largely upon the nature of the work in question. A can suspended under the machine suffices in some instances to catch the oil. As the can fills with waste oil, it is removed and is emptied into the can above the machine. Some machines are equipped with catch pans and troughs for collecting the used oil; and where the work is of such nature as to necessitate the removal of chips before reusing the oil, the removal is accomplished by means of wire screens, perforated steel plates, or dividing baffle plates in the reservoirs, over which the oil must flow when it is pumped. Drain pipes attached to the collecting pans and troughs are sometimes used to convey the oil to the central supply system. Troughs of wood or of concrete built in the floor often serve the same purpose; and outlet pipes through the floor discharge the oil into a collecting reservoir suspended from the ceiling of the room below.

In the larger plants the oils constitute a considerable item of expense, which is greater than it should be because the chips and turnings from metal-working machines retain considerable oil which might be reused. Various methods of minimizing this waste, such as centrifugalization, sedimentation, filtration, straining, magnetization, and combination of any or all of these methods have been devised. A Detroit automobile plant which uses approximately 1,300 gallons of oil daily is said to reclaim 500 gallons. These various methods are here briefly described.

Centrifugalization.—The chips, turnings, and metal parts which retain the oil are placed in strainers, where as much as possible of the oil is drawn off through grids, and the chips are then placed in rotating containers in the centrifugal separators. The centrifugal action throws the oil away from the chips, and it is thus reclaimed. In many cases the oil-covered chips are subjected in the centrifuges to the heat of steam, which has a tendency to make the oil less viscous and more easily removed. By this means the oils may also be sterilized. A subsequent centrifugalization is necessary to separate the oil and water. The water is frequently evaporated, by passing the mixture through a filtering medium to a set of steam-heated coils, which surround the filtering chamber. In some plants all the oil (as well as the chips) is treated by centrifugalization, in order to remove dirt and other foreign matter.

Sedimentation.—By sedimentation the foreign soluble substances in the oil are caused to settle at the bottom of the tank, and the oil may pass over baffle plates into an outlet reservoir.

Filtration.—By filtration the oil may either be forced through the filtering medium under pressure, or may pass through by gravity. An objection to this method is that the pores of the filter become clogged with chips, and thus the passage of the oil is prevented.

Straining.—By the straining method the larger chips and pieces of metal are strained off by running the oil through grids or perforated plates.

Magnetization.—In magnetization the oil is passed in a shallow stream over a magnetized plate, which draws out all metallic particles. The surface of the magnetized plate is automatically cleaned from metallic particles.

Combined systems.—Frequently two or more of the above systems are used in combination, and such combinations prove to be very efficient in removing the metallic particles.

STERILIZATION OF OILS.

Much emphasis has been given to the sterilization of oils, which is based upon the theory that if the pathogenic organisms which frequently contaminate the oils are killed, the incidence of cutting-oil skin affections will be reduced or entirely eliminated.

The sterilization of oils is accomplished in two ways. First, by means of heat, which is perhaps the most efficient and at the same time the cheapest method available. If the oil is maintained at a temperature of 145° F. for 30 minutes, the more common pathogenic bacteria are killed, and only the more resistant spore-forming, air-borne bacteria remain. Many devices are used to attain heat sterilization of oils and compounds. The most popular device is that of passing live steam through coils of pipe constructed within a large tank, through which the oil flows or is pumped. A second method is that of chemical sterilization. The chemicals generally used for sterilization are phenol, cresol, and other coal-tar derivatives. These, however, are expensive, and when used in concentration sufficient to be efficacious, not infrequently cause a dermatitis themselves. The use of inorganic and metallic germicides, such as mercuric chloride, copper sulphate, silver nitrate, and ferrous sulphate, is restricted because of their corrosive action on the metal with which they come in contact. Oxidizing and reducing agents, such as potassium permanganate, hydrogen peroxide, sulphur dioxide, iodine, bromine, chlorine, and ozone, are not effective germicides because of their lack of stability, and because of the presence of organic matter in the oils and compounds. Chloroform, iodoform, and alcohol are too unstable and too costly. Alkaloids are unsuitable.

The concentration of the chemical to be used depends a great deal upon the character of the oil or compound.

In the report of 1918 of the Commission of the English Ministry of Munitions, phenol or other coal-tar antiseptic, to 1 per cent, is recommended as an effective agent in reducing the bacterial content of oils.

Albaugh, of the Ohio State Department of Health, and Deeds, of the United States Public Health Service, carried on a number of experiments to determine the efficacy of methods of sterilization. The conclusions were that the majority of the available chemical disinfectants are capable of causing a dermatitis when in sufficient concentration or over a period of time; hence, very carefully controlled experimentation with the oil in question is necessary before any recommendation is made as to a chemical disinfectant. The concentration required to set up this dermatitis will vary with the individual workman, and with the oil used, as well as with the character of the operation, since some operations and machines are more prone to splash the oil.

COMBINED STERILIZATION.

It appears that the ideal method for sterilizing the oil would be to combine the heat and the chemical methods. This would afford a constant sterilizing process by the chemical as well as an intermittent one by the heat. The required concentration of the chemical would undoubtedly be much less in this method.

Part II. Cutting Oil Dermatosis.

PREVALENCE.

An examination of the arms and forearms of 2,060 workers whose occupations require contact with one or more of a large variety of cutting oils and lubricating compounds, disclosed the fact that 557, or about 27 per cent, of these workers were suffering from a dermatosis characteristic among metal-cutting operatives. Forty-two of these workers had skin lesions, such as scabies, psoriasis, and other skin affections, which could not be attributed to the use of cutting liquids. This percentage attests the prevalence of the dermatosis in all metal-cutting industries where lubricating compounds are used, according to recent information received from the large plants in the United States. Certain preventive measures which are described in this part of the report were recommended to several plant managers who cooperated with the Public Health Service in this investigation, and in those plants where these measures were consistently carried out, the skin affections ascribed to cutting liquids entirely disappeared. After a period of eight months the writer had the opportunity to visit these plants again and to reexamine the workmen, many of whom had been seen previously, and the effectiveness of the measures was sufficiently demonstrated to assure their adequacy.

DESCRIPTION OF LESIONS.

The skin affection, frequently referred to as "oil acne" or "oil pimples," appears primarily as comedones, situated in the orifices of the hair follicles. Each comedo is followed by a reddish, circumscribed, macular lesion, with a tendency to slight elevation. These lesions are oval in contour, varying in size from one to three millimeters in diameter. They rapidly develop into papular lesions, approximately the size of a pea, with circular bases and conical tops through which the cilia protrude. The lesions are hard in consistency, are discrete, and are distributed for the most part along the dorsum of the hands, the dorsal and ventral surfaces of the forearms, and the anterior surfaces of the thighs. Among workers who have the habit of brushing the hair back with the hand, the forehead and face are additional sites of the lesions. In fact, wherever the cutting liquids come in contact with the skin, the dermatosis is likely to appear.

SYMPTOMS.

There are no accompanying constitutional symptoms, and the only subjective symptoms complained of in uncomplicated cases is itching, which is very intense at times. On expression, these papules discharge a hard, sebaceous substance. After the maculo-papular eruption appears, one of two things usually happens: The lesions either retrogress or become infected and develop into pustules and abscesses. In rare instances, when the initial lesions do not retrogress, they continue to grow into varying-sized tubercles, which are apparently neoplastic in type, and are of a very firm consistence and pinkish in color. Three of the cases examined showed lesions of this type.

PREVIOUS STUDIES OF CUTTING-OIL DERMATOSIS.

While the study of skin affections attributable to the use of cutting-oils and lubricating compounds is of recent date, because of the comparatively late adoption of such materials into common industrial usage, dermatic affections and other occupational skin diseases caused by the components and the forerunners of the modern cutting oils and compounds were studied as long ago as 1887, in which year White [3] came to the conclusion, as the result of his researches into the effects of petroleum on the skin, that crude petroleum was not able of itself to produce the scarlatinoid eruptions and the furunculosis which were reported among oil-refinery workers, but that the products obtained by the refining of the oil were possibly responsible for the skin diseases. This work was practically the first intensive research conducted upon the subject, although in the previous year (1886) Rémy and Broca [4] reported their studies upon the incidence of dermatic affections among oil-refinery workers.

In 1888 Lewin [5] published the results of his studies of cutaneous poisoning by petroleum. He found among refinery workers many cases of acneform lesions as well as of furuncles, which were localized chiefly upon the upper leg, the knee, and the arm. He ascribes the causation of the affection to the lighter oils or petroleum distillates, rather than to petroleum itself.

Blascho [6] found the affection existing among printers who have to do with the cleaning and oiling of the big machines and among polishers of furniture.

Alfeld and Fischel [7] observed the same condition among factory workers, polishers, belt makers, and turners, and attributed the cause to bad petroleum.

Bettman [8] classifies the lesions into four types, as follows:

1. A sluggish, often itching, folliculitis.
2. Follicular keratosis.

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[3] White, James Clarke: Dermatitis Venenata, p. 151. Boston, 1887.

[4] Remy and Broca: Sur l'ecthyma des raffineurs. Revue de Chirurgie, VI, p. 717-723. Paris, 1886.

[5] Lewin, L.: Ueber Allgemeine und Hautvergiftung durch Petroleum. Virchows Archiv., B. C. VII, H. 1, pp. 35-69. Berlin, 1888.

[6] Berliner dermatologische Gesellschaft, Dermatologische Zeitschrift, vol. XVIII, p. 70. Berlin, 1911.

[7] *Ibid.*

[8] Bettmann: The Injurious Effects of Oils and Vaselines on the Skin. Jour. of Ind. Hyg., vol. I, No. 8, p. 129 of Abstracts. December, 1919.

3. Melanoderma of exposed skin surfaces.
4. Circumscribed warty areas.

Dr. B. F. Davis,[9] in describing the lesions found in the case of men employed in pressrooms where crude paraffin is run into presses for expressing the oils, states: "The paraffin remaining in the press, so-called slack wax, is scraped off by men who use spadelike instruments and usually work barehanded with sleeves rolled up above the elbows. During this process the men become pretty thoroughly smeared with the pressed distillate. During the first few months of employment in this department the majority of workmen suffer from 'wax-boils,' affecting any portion of the skin, but particularly the arms and neck. The susceptibility to this trouble, which appears to be a species of furunculosis, may disappear in time, to a very large extent. A certain proportion of workmen, however, will develop still further lesions. Thus, after a number of years, pigmented spots make their appearance; some of them are scaling and psoriatic, others merely rust-colored areas varying in diameter from a few millimeters to a centimeter and a half (these may be of slow development, amenable to various common remedial measures); finally true epithelioma may appear."

Since the advent of cutting oils and lubricating compounds, as now used, there has been a revival of the study of the subject of occupational dermatoses formerly attributed to the forerunners of these agents. This renewed interest, which has resulted in more energetic reporting of cases of this nature, has been the source of an impression that there is at present a greater proportional incidence of such cases than in the past, although in reality not much evidence has been presented to substantiate this opinion.

SCOPE AND PROCEDURE OF THIS INVESTIGATION.

As has been previously stated, the purpose of this investigation was to determine, if possible, the exact cause of the skin affection and to devise practical methods of prevention. Before the actual field work was commenced, questionnaires were sent to manufacturers who used oils and lubricating compounds in their plant processes for metal-cutting operations, with requests for information as to the approximate number of workers affected with the dermatosis, and as to whether or not the manufacturer would cooperate with the service by granting permission to its investigators to study in their plants the conditions from which the affection arose. Nearly 500 of the questionnaires were answered and returned. A selection of the plants using the greatest variety of oils, of methods for distributing, reclaiming, and sterilizing the oils, and of other salient features was made, and these plants were visited.

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[9] Davis, B. F., in the Journal of the American Medical Association, vol. 75, No. 25, p. 1710. Dec. 18, 1920.

Throughout the course of the investigation careful note was made of information obtained in each plant, relative to working conditions, processes, oils in use, methods of applying, collecting, reclaiming, sterilizing, and straining them, and to physical examination of employees.

A careful analysis of the data collected was made to ascertain, if possible, the factor or factors incident to the dermatosis or contributing to its etiology. Consideration was also given to contending theories adduced to explain the causation of the skin eruption.

THEORY OF PREVENTION.

On the hypothesis, based upon the analysis made (the analysis is discussed in a subsequent part of this report), that the dermatosis is due largely to a mechanical obstruction of the sebaceous ducts induced by extraneous matter in the oil and by other foreign material or dirt which can be found on the forearms and hands of almost any workman, the deduction naturally followed that the principle of prevention depended upon some method of restraining the ingress of the foreign matter.

As a preventive, previous writers on the subject have recommended the frequent cleansing of the hands and forearms with the application of some emollient after the day's work. In the writer's opinion, this routine is equivalent to giving typhoid vaccine after the fever has developed; it is instituting treatment after the injury has been done; it is not preventive. The emollients tend to inhibit further the natural functions of the skin, and at a time when the necessity is not urgent.

PREVENTIVE MEASURES.

In those plants where the study was made the practice was instituted of rubbing well into the orifices and crevices of the skin of the hands and forearms a clean preparation of lanolin or a mixture of equal parts of lanolin and castor oil before the work period began. It was noted, however, that while this measure prevented the ingress of the cutting oils and lubricating compounds, it also had a tendency to force further into the orifices the dirt already present on the surfaces. To obviate this difficulty the workmen were instructed to wash the hands and forearms well before applying the lanolin. Warm water and a mixture (in equal parts) of sawdust and liquid soap were supplied. The mixture of sawdust and soap has not only a cleansing action on the skin but also a psychic effect on the men, and they are apt to be more thorough in applying the soaped sawdust to all parts, not merely "hitting the high spots," so to speak.

The improvement of the skin lesions from this procedure was so noticeable that the following routine measures were recommended:

1. On entering the plant each workman should wash the hands and forearms thoroughly with warm water, using a sawdust and liquid-soap preparation to assist the cleansing process.
2. After drying skin with individual towel he should apply either lanolin alone or lanolin and castor oil, and rub well into the skin.
3. Foreman should inspect each worker as he enters the workshop, to insure the efficient carrying out of the foregoing instructions.
4. At noon, before eating luncheon, the workmen should wash hands and forearms with warm water and soap.
5. On returning to work they should repeat the morning schedule of washing and applying the lanolin preparation.
6. At the end of the workday they should wash hands and arms with warm water and soap and dry them. No emollients should be applied unless actual abrasions are present, in which event proper dressings should be applied.

The lesions on the thighs can best be prevented by wearing aprons impenetrable to oils.

Results.—In plants where this routine was enforced the cases of dermatosis disappeared in a short time, and eight months after the institution of the routine physical examinations of many of the same workers examined in the beginning of this study failed to disclose any new cases of the dermatosis.

On the other hand, in plants where the routine measures had been adopted but not enforced, cases still existed, and the men affected admitted, when questioned, that they had discontinued the measures, or had neglected to use them, some because it was too much bother, others because they had to wait in line too long or because enough time was not given or for other reasons equally trivial.

Table V shows the results of these experiments.

TABLE V.—*Cases of cutting-oil dermatosis.*

Preventive measures—	Plant No.	Number of cases on first visit.	Number of men originally examined still on the job 8 months later.	Number of cases 8 months later.	Per cent still with dermatosis.
Enforced	1	85	74	0	
	3	16	8	0	
	[1]6	94	9	0	
Total		195	91	0	0.0
Available, not enforced	2	62	29	7	
	5	20	18	3	
Total		82	47	10	21.3
Recommended, not supplied	4	70	25	12	48.0

[1] Force diminished to 50, only 9 of original examinees working.

The preventive measures were carried out in various other plants, in which, on account of reduction of force or suspension of work, it is not possible to attribute the reduction in number of cases to the use of preventive measures, and these plants are therefore not included in the table.

The fact that, in plants enforcing the measures, the dermatosis disappeared and no new cases developed, conclusively demonstrates at least the effectiveness of the procedure if not the exciting factors concerned in the development of the eruptions.

THEORIES AND HYPOTHESES.

In an investigation of this nature so many variable factors are encountered that it is difficult to separate them and to obtain data which would place the subject on a scientific basis. Again, the investigator must not lose sight of the personal equation of the worker and of the realization that the protection afforded the skin varies with the individual and his environment. Previous occupations and injuries may have changed or damaged the protective quality of the skin in some individuals or may have created an unfavorable vascular disturbance. The infectious and the chemical or irritant theories both have their advocates.

Infectious theory.—This theory expresses the belief that cutting oils and lubricating compounds support the growth of pyogenic microorganisms, and that these are conveyed by the oils and compounds to the skin of the workmen engaged in processes where cutting mediums are used. The theory assumes that the bacteria secure entrance to the skin through minute punctures made by the metal chips carried by the oil to the body. If this theory were true, the dermatosis would be prevented by the removal of the bacteria and chips from the oil, or by the addition to the oils and lubricating compounds of a disinfectant or germicide. Some plants have incurred the expense of installing a sterilizing system, and have also tried removing the metal chips by magnetism. Two such plants were investigated, and in one of them 30 per cent and in the other 22 per cent of the workers had the dermatosis. The foremen stated that they had noticed no marked difference in the incidence of the cases before and after the installation of the system.

Much time was spent during the present investigation in determining the efficacy of heat sterilization and the effectiveness of germicides and disinfectants. Scientific Assistant Forrest E. Deeds conducted a series of tests which proved that heat sterilization of oils and compounds is possible, and that a 0.5 per cent solution of either phenol or cresol in the cutting oils and compounds is fairly efficient in eliminating the bacteria. However, as stated above, the dermatosis is not prevented by either sterilization or the use of germicides and disinfectants.

Further proof against the infectious theory seems to lie in the fact that smears taken aseptically from the papular eruptions failed to show the presence of bacteria. Dr. Kendall,[10] professor of bacteriology at Northwestern University, in a similar study, likewise was unable to find bacteria present. Moreover, if the dermatosis were primarily an infection resulting from the use of contaminated oils and compounds, direct evidence of well-defined epidemics of furunculosis, the number of cases approximating reasonably the number of exposures, in all probability would follow.

Secondary infections.—That infections, however, frequently complicate the initial dermatosis can not be disputed; and the occurrences of these infections has led many observers to the erroneous conclusion that the infections are primary. Careful inquiry into the progress of the infections found among the workers examined in this investigation brought forth the information that the primary lesions appear as here described and that the infections follow the opening or scratching of the lesions. The derived lesions vary according to the infecting organism. While it is not the purpose of this article to advance arguments respecting the source of these secondary infections, our bacteriological experiments have failed to incriminate the oils and compounds as the necessary carriers of the infection. Organisms are usually found, it is true, in the cutting oils and compounds which are reused, but in no greater number nor variety than those which are found normally on the body surface and in the air. Besides, irrespective of this source, bacteria can do no harm until they have secured ingress to the skin. The habits of the individual contribute largely as an exciting cause of the infection. The itching which is associated with the dermatosis causes the workers to scratch, and it is not unusual for them to squeeze and pick the papules, because they are annoyed by the unsightly appearance of the black spot at the bases of these. It was noticed that many of the men spent from 10 to 20 minutes in an hour either scratching or picking at the skin lesions. The possibility of producing minute abrasions by the habit thus described is obvious. Moreover, the oils, which are frequently of a high temperature when they reach the skin surface, sometimes produce minute burns, which favor the ingress of bacteria. Again, the ever-increasing distention of the sebaceous ducts, caused by the impacted solid matter and secretions, offers favorable lodgment to the organisms; and the multiplication and growth of these are promoted by the lowered resistance and vitality of the lining cells.

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[10] Causes of Skin Sores and Boils Among Metal Workers. Houghton Research Staff, p. 16.

Chemical theory.—Another theory, which has been gaining in popularity of late, would explain the causation of the dermatosis as the result of the chemical or irritant action of the cutting liquids.

The multiplicity of oils and lubricating compounds in use, as emphasized in the first section of this report, evinces the futility of attempting to isolate any one oil or compound or group of compounds as responsible for the dermatosis. It can not be denied, as shown by an analysis of the oils, that certain ingredients found in some of the oils are not capable of producing a dermatosis. The free fatty acids, hydrocarbon sulphonates, alkali, and unsaturated hydrocarbons are often mentioned as agents responsible for the trouble. Another fact which may influence the chemical content of the oils and compounds used as lubricants and coolants in the metal-working industry, is that the various metals used for making rods, bars, and other parts of machinery, are pickled before they leave the rolling mill, and such chemicals as are used for pickling may be carried by the metal. These chemicals may easily be removed from the metal by the oils and compounds as they pass over it, and in this manner the oils and compounds may become carriers of the chemicals.

While it is admitted that some oils may have an irritant action on the skin, examination of the primary skin lesions fails to reveal the presence of an inflammation, such as might be expected from this irritation. Furthermore, chemical irritants would in all probability act upon the intrafollicular spaces as well where, however, no irritation is found, and the lesions would perhaps vary according to the chemical agent used. Irritating oils and compounds unquestionably aggravate the trouble, but proof that they do not necessarily cause the dermatosis lies in the fact that men working in coal dust or in any inert powder frequently develop identically the same sort of skin lesions.

Mechanical obstruction of sebaceous ducts in dry-skinned individuals.—The theory that the affection is caused by mechanical obstruction of the sebaceous ducts in dry-skinned individuals seems best fitted to the facts recorded in this investigation. In order to determine the presence of distinguishing factors, a comparison was made of the physical and dermatological differences between workmen with the dermatosis and workmen not so troubled, while operating the same machines and working under the same conditions. The condition of health apparently exerted no influence. Many very healthy looking individuals were found to have the dermatosis, whereas, on the other hand, many very lean workmen were not affected, and vice versa. Age, length of exposure, diet, complexion, and other characteristics were studied with reference to points of likeness and unlikeness, but the only feature of difference discernible was the dryness of the skin in a large majority of persons with the dermatosis and the oiliness of the skin in those who did not have it.

While the task of distinguishing the extremes of these conditions is comparatively easy, many individuals are found whose skin would be considered dry by some and oily by others. The investigator, in making a decision in these border-line cases, considered the opinion of the worker himself and that of others in the immediate vicinity, together with his own. In unquestionable cases of naturally dry skin the dermatosis was observed, and in cases of unquestionable oily skin the dermatosis did not exist. Individuals of the latter class may in time develop the dermatosis, because of the desiccating power of many of the oils as suggested by Collis.[11] This is a plausible explanation, also, of the fact that some workers develop the skin lesions early and others later. Those with very dry skin develop the lesions rapidly, while those with a greater degree of oiliness require a greater length of time. In a previous paper on industrial dermatosis among plate printers the writer has called attention to these dermatological differences and to the tendency of individuals with dry skin to develop the dermatosis.[12]

SUMMARY.

In this report attention has been particularly directed toward the practical method of preventing the dermatosis, but it is realized that only a minimum reduction in the number of cases is affected by merely recommending preventives to the workmen without providing adequate sanitary arrangements and employing responsible supervision.

The weight of the evidence collected in this investigation incriminates oils and lubricating compounds of all types carrying extraneous matter in suspension as the primary cause in producing the initial dermatosis by mechanical obstruction of the sebaceous orifices, the underlying or basic cause being a deficiency of the natural oiliness of the skin. Infecting organisms, which usually inhabit the body surface, but which may be carried by cutting liquids, frequently find ingress to the skin through the primary dermatic lesions by reason of the sufferer's scratching the affected surface or by reason of other irritation, and thereby produce a secondary infection of the dermatosis as a complication.

In other cases the abrasions produced by particles of the metal become infected and complicate the dermatosis. The condition so arising is not, however, allied to the primary dermatosis, but is similar to conditions which would be classified under the head of abrasions and infections, such as are commonly found wherever bacteria are present.

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[11] Collis, E. L.: Dermatitis caused in the manufacture of roll tobacco. Annual Report of Chief Inspector of Factories and Workshops of Great Britain, 1910, p. 194.

[12] Industrial Dermatosis among Printers. Public Health Reports, vol.36, No. 18, May 6, 1921. Reprint No. 656.

Prevention depends, first, upon thorough cleanliness, and, second, upon the application of lanolin or lanolin and castor oil to the skin at the beginning of the work period.

Cure is accomplished by rest of the affected parts and by constant use of the preventive measures.

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RURAL HEALTH SERVICE IN THE UNITED STATES.

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According to data obtained by the Rural Sanitation Office of the Public Health Service from the health departments of the States, the following (Table I) is a list, by States, of counties (or districts) in which the rural sections thereof at the beginning of the calendar years 1920, 1921, and 1922, respectively, were provided with local health service under the administration of whole-time county or district health officers: